NOAA, National Ocean Service
Center for Operational Oceanographic Products and Services
Specifications and Deliverables for Installation,
Operation, and Removal of Water Level Stations

1. Introduction

1.1. NOS National Water Level Observation Network

CO-OPS manages the National Water Level Observation Network (NWLON) of approximately 175 continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with satellite radios, near real-time (within about 1 hour of collection at most stations) raw data are made available to all users through the interface to the CO-OPS Home Page on the Web. Verified products, such as edited 6-minute data, hourly heights, high and low waters, and monthly means are made available over the Web within one to four weeks after data collection. NWLON data and accepted tidal datums are used in hydrographic surveys either to provide tide reducers directly or for control for datum determination at subordinate (short-term) stations. Preliminary and verified data are made available over the Web relative to MLLW datum as a user option in the interface.

1.2. Data Quality Monitoring

CO-OPS has an in-place Continuous Operational Real-Time Monitoring System (CORMS) that provides quality control and system monitoring functions on a 24 hour/day, 7-day/week basis. CORMS will provide monitoring of the status and performance of all stations equipped with satellite radios using the NOS satellite message format installed by the contractor, as it does for all other NOS water level systems, including all NWLON stations. The CORMS system description is found in *System Development Plan, CORMS.* CORMS is a NOS provided support function to the operational field parties and does not relieve the contractor of responsibility for performing QC and ensuring proper gauge operation.

1.3. General Data and Reference Datum Requirements

The present NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) based on the NOAA National Tidal Datum Epoch (NTDE) of 1983-2001 as defined in the *Tide and Current Glossary*. All tidal datum computations and water level reductions shall be referenced to this datum. In non-tidal areas, including the Great Lakes, special low water datums have been defined for specific areas and are used as chart datum in these locations.

In some cases where historical sites are re-occupied, site datum shall be zeroed to a pre-established MLLW datum held on a bench mark. In that case, data can be acquired relative to MLLW. At present, in Great Lakes areas, a special Low Water Datum relative to IGLD 85 is the reference datum.

2. Water Level Station Requirements

2.1. Data Collection and Field Work

The contractor shall collect continuous, good and valid data series. Accurate datums cannot be computed for a month of data with a break in the water level measurement series in excess of three days. Even breaks of significantly less than three days duration will not allow for interpolation during times when strong meteorological conditions are present and in areas with little periodic tidal influence. Any break in the water level measurement series affects the accuracy of datum computations. At a critical measurement site where the water level measurement data cannot be transmitted or monitored during project operations, an independent backup sensor or a complete redundant water level collection system should be installed and operated during the project.

2.2. Water Level Sensor and Data Collection Platform

The water level sensor shall be a self-calibrating air acoustic, pressure (vented), or other suitable type. The sensor measurement range shall be greater than the expected range of water level. Gauge/sensor systems shall be calibrated prior to deployment, and the calibration shall be checked after removal from operations. The calibration standard's accuracy must be traceable to National Institute of Standards and technology (NIST). The required water level sensor resolution is a function of the tidal range of the area in which hydrographic surveys are planned. For tidal range less than or equal to 5 m, the required water level sensor resolution shall be 1 mm or better; for tidal range between 5 m and 10 m, the required water level sensor resolution shall be 3 mm or better; and for tidal range greater than 10 m, the required water level sensor resolution shall be 5 mm or better.

The Data Collection Platform (DCP) shall acquire and store water level measurements at every 6- minutes. The water level measurements shall consist of an average of at least three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples which comprise the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data is required for compatibility with the NWLON stations, and the standard deviation provides valuable data quality information regarding each measurement. The clock accuracy of a satellite radio system shall be within 5 seconds per month so that channel "stepping" does not occur. Non-satellite radio systems shall have a clock accuracy of within one minute per month. Known error sources for each sensor shall be handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types.

The NOS is currently using the Aquatrak® self-calibrating air acoustic sensors at the majority of the NWLON stations. (For further information refer to *Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual*, NOAA/NOS, January 1991 and *User's Guide for 8200 Acoustic Gauges*, NOAA/NOS, Updated August 1998). At stations where the acoustic sensor can not be used due to freezing or the lack of a suitable structure, either a ParoScientific intelligent pressure (vented) sensor incorporated into a gas purge system, or a well/float with absolute shaft angle encoder (Great Lakes Stations) are used for water level measurements. (For further information refer to *User's Guide for 8200 Bubbler Gauges*, NOAA/NOS, Updated February 1998).

In each and any case, the water leveling sampling/averaging scheme shall be as described above. For short term subordinate stations which are installed to support NOS hydrographic surveys, the use of air acoustic sensor is preferred over pressure sensor whenever possible. Where the air acoustic sensor can not be installed, NOS uses a vented strain gauge pressure sensor in a bubbler configuration (Refer to *User's Guide for 8200 Bubbler Gauges*, NOAA/NOS, updated February 1998). When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start, (2) at frequent intervals during deployment, and (3) at the end of a deployment. Frequent gauge/staff comparisons (at least two times per week or minimum eight times per month) during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations shall be at least three hours long at the beginning and end of deployment and the periodic observations during deployment shall be 1 hour long. Along with the averaging procedure described above which works as a digital filter, NOS uses a combination protective well/parallel plate assembly on the acoustic sensor and a parallel plate assembly (with 2" orifice chamber) on the bubbler orifice sensor to minimize systematic measurement errors due to wave effects and current effects, as shown in figure 1.

2.3. Data Transmissions

The ability to monitor water level measurement system performance for near real-time quality assurance is essential for operations. Water level data transmitted via satellite in NOS format can be retrieved and monitored by CO-OPS, and in the case of data gaps or gauge problems, corrective actions can be taken immediately. Therefore, it is required that, where access to the satellite is available, the measurement system be equipped with a GOES transmitter to telemeter the data to NOS every one/three hour(s). The data transmissions must use a message format identical to the format as currently implemented in NOS' Next Generation Water Level Measurement Systems (NGWLMS). This is required to assure direct compatibility with the NOS Data Management System (DMS). This data format is detailed in the reference document "NGWLMS GOES MESSAGE FORMATTING" (see Section 5 for References). The NOS Continuous Operational Real-Time System (CORMS) will monitor all water level measurement system GOES transmissions to assure they are operating properly, provided the GOES data transmitted is compatible with NOS format. Data that is not transmitted by GOES or data transmitted but not in NOS compatible GOES format, but is submitted to CO-OPS via diskette, CD-ROM, or such other media, must also conform to the format specified in the above document so that data can be loaded properly into DMS.

Close coordination is required between contractor and Requirements and Development Division (RDD) of CO-OPS for all water level installations with satellite transmission capability. NOS will assist in acquiring assigned platform ID's, time slots, etc. At least three business days prior to the initiation of GOES data transmission in the field, information about the station number, station name, latitude, longitude, platform-ID, transmit time, channel, and serial numbers of sensors, and DCP shall be faxed, phoned, or sent to RDD. Test transmissions conducted on site are outside this requirement. This station and DCP information must be configured in DMS before data transmissions begin so that the data will be accepted in DMS. The documentation required prior to transmission in field is defined in the NGWLMS Site Report, Field Tide Note, or Water Level Station Report, as appropriate (see Section 5 for References).

2.4. Station Installations

Contractors shall obtain all required permits and permissions for installation of the water level sensor(s), Data Collection Platforms (DCP), bench marks, and utilities, as required. The contractor shall be responsible for security and/or protective measures, as required. The contractor shall install all components in the manner prescribed by manufacturer, or installation manuals. The contractor must provide CO-OPS of the position of all tide gauges installed before data collection begins, including those that were not specified in the Statement of Work. In cases where gauge location(s) needs to be different than that specified in the Statement of Work, contractor shall consult with CO-OPS prior to the installation.

The following provides general information regarding station installation, operations and maintenance, and station removal.

Station Installation

A complete water level measurement station installation consists of the following:

(a) The installation of the water level measurement system (water level sensor(s), DCP, and satellite transmitter) and its supporting structure and a tide staff, if required.

(b) The recovery and/or installation of a minimum number of bench marks and a level connection between the bench marks and the water level sensor(s), or tide staff as appropriate.

(c) The preparation of all documentation and forms.

Bubbler Orifice and Parallel Plate Assembly

This assembly is made from red brass, its properties prevent the growth of marine life by the slow release of copper oxide on its medal surface. A Swagelok® hose fitting is screwed into the top end cap this hose is used to charge the orifice with Nitrogen gas. The Nitrogen gas flows out the bottom of the orifice at a rate sufficient to overcome the rate of tidal change, and wave height, this opening establishes the level point for tidal measurements. The parallel plates produce a laminar flow across the orifice to prevent venturi effect. A two inch by eight inch pipe provides the correct volume gas for widest range of serf conditions encountered by most coastal surveys.

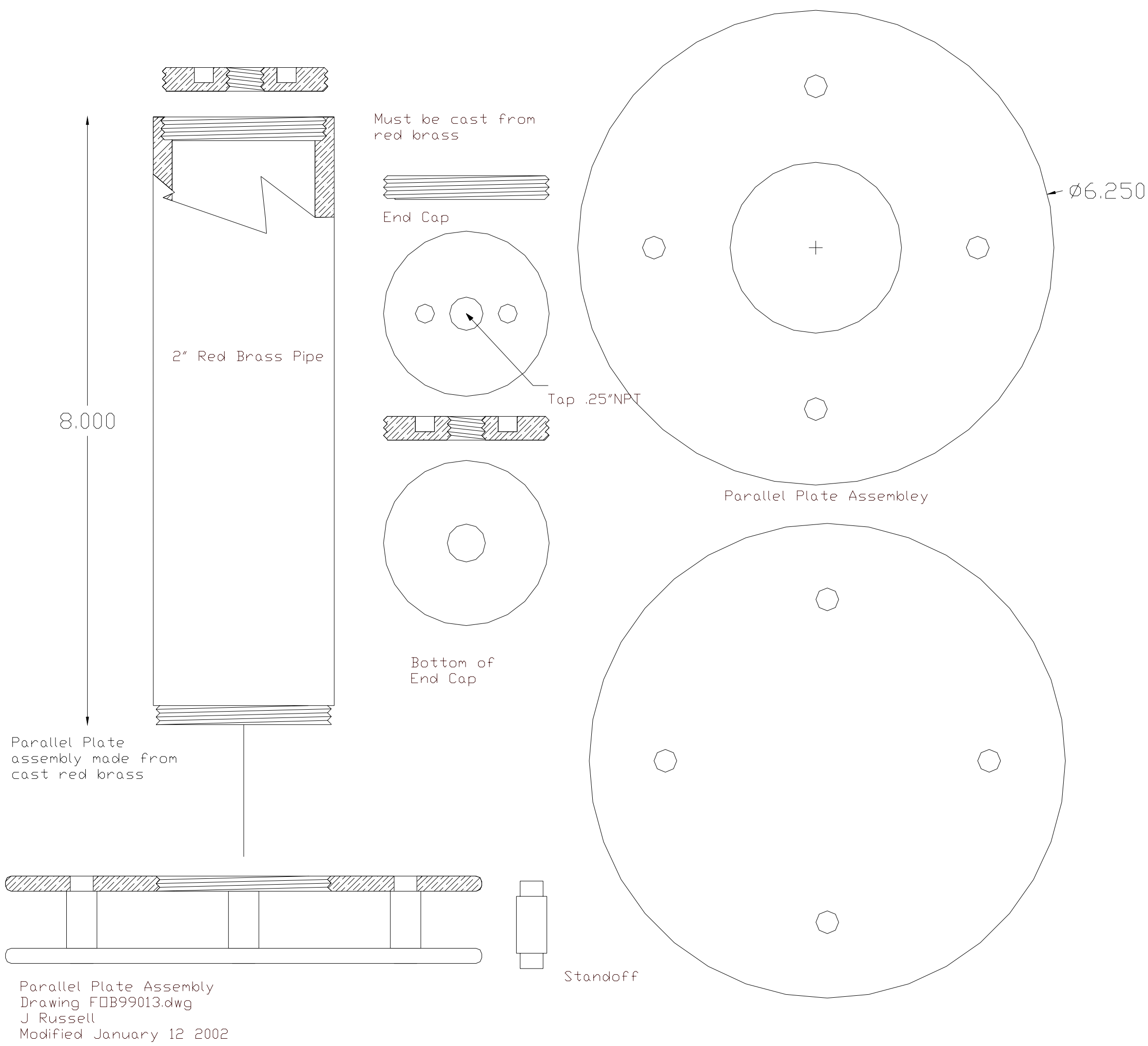


Figure 1 : Bubbler orifice bottom assembly

2.5. Operation and Maintenance

When GOES telemetry and NOS satellite message format is used, the contractor shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure and for other causes of degraded or invalid data, such as marine fouling. This monitoring can be performed by accessing the CO-OPS web page **(http://www.CO-OPS.NOS.NOAA.GOV).** The data over this system are typically available for review within two to four hours after collection.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate maintenance forms (refer to Section 4 water level station documentation) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time of start and completion of the maintenance activity; date and time of adjustments in sensor/DCP, datum offset, or time; personnel conducting the work; parts or components replaced; component serial numbers; tests performed; etc.

2.6. Gauge Removals

A complete removal of the water level measurement station consists of the following:

(a) Closing levels - a level connection between the bench marks and the water level sensor(s) and/or tide staff.

(b) Removal of the water level measurement system and restoration of the premises, reasonable wear and tear excepted.

(c) The preparation of all documentation, forms, data, and reports.

3. Bench Mark and Leveling Requirements

3.1. Number and Type of Marks

A bench mark is a fixed physical object or marker (monumentation) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks in the vicinity of a water level measurement station are used as the reference for the local tidal datums derived from the water level data. The relationship between the bench marks and the water level sensor or tide staff shall be established by differential leveling.

3.2. Number and Type of Bench Marks

The number and type of bench marks required depends on the duration of the water level measurements. The *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* specifies the installation and documentation requirements for the bench marks.

Each station will have one bench mark designated as the primary bench mark (PBM), which shall be leveled to on every run. The PBM is typically the most stable mark in close proximity to the water level measurement station. The contractor shall select a PBM at sites where the PBM has not already been designated. At historic stations where NOS has prior data and information, CO-OPS will designate the PBM and provide to contractor the PBM above station datum elevation that needs to be used in the level operations and on the level abstracts. If the PBM is determined to be unstable, another mark shall be designated as PBM. The date of change and the elevation difference between the old and new PBM shall be documented. NOAA will furnish the individual NOS standard bench mark disks to be installed.

3.3. Leveling Standards

At least third-order levels shall be run at short-term subordinate stations operated for less than one-year. Requirements for higher order levels will be specified in individual project instructions. Standards and specifications for leveling are found in *Standards and Specifications for Geodetic Control Networks* and *Geodetic Leveling (NOAA Manual NOS NGS 3)*. Additional field procedures used by NOS for leveling at tide stations are found in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations*. Electronic digital/barcode level systems are acceptable. Specifications and standards for digital levels are also found in *Standards and Specifications for Geodetic Control Networks* and additional field procedures used by NOS for electronic leveling at water level stations are found in the *User's Guide for Electronic Levels* (refer to Section 5 for references).

3.4. Leveling Frequency

Levels shall be run between the water level sensor(s) or tide staff and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, or staff or orifice replaced), for bracketing purposes, or prior to removal. In any case, levels are required at a maximum interval of six (6) months during the station's operation, and are recommended after storms to check and document stability (stability discussed below).

Bracketing levels to appropriate number of marks (five for subordinate stations) are required after 6 months for stations collecting data for long term hydrographic projects.

3.5. Stability

If there is an unresolved movement of the water level sensor or tide staff zero relative to the PBM, from one leveling to the next, of greater than 0.006 m, the contractor shall verify the apparent movement by re-running the levels between the sensor zero or tide staff to the PBM. This threshold of 6 mm should not be confused with the closure tolerances used for the order and class of leveling.

3.6. Geodetic Datum Relationship

Tidal datums are local vertical datums which may change considerably within a geographical area. A geodetic datum is a fixed plane of reference for vertical control of land elevations. The North American Vertical Datum of 1988 (NAVD 88) is the accepted geodetic reference datum of the National Geodetic Spatial Reference System and is officially supported by the National Geodetic Survey (NGS) through a network of GPS continuously operating reference stations. The relationship of tidal datums to NAVD has many hydrographic, coastal mapping and engineering applications including monitoring sea level change and the deployment of GPS electronic chart display and information systems.

Existing geodetic marks in the vicinity of a subordinate tidal station shall be searched for and recovered. A search routine is available at http://www.ngs.noaa.gov. An orthometric level connection and ellipsoidal GPS tie is required at a subordinate tide station which has geodetic bench marks located nearby. NAVD 88 height elevations for published bench marks are given in Helmert orthometric height units by NGS. The GPS ellipsoid network height accuracies are classified as conforming to 2 cm or 5 cm standards accuracies (Refer to *NOAA Technical Memorandum NOS NGS-58*). At the present time, GPS ellipsoid heights conforming to the 5 cm accuracy standards are required for contract water level projects, but in the near future NOAA may switch to 2 cm accuracy standards for contract water level projects as the GPS technologies progress. Contractors are cautioned to study the differences in the 2 cm versus 5 cm accuracy standards and as far as GPS equipment is considered, fixed height pole GPS antennas are recommended even for 5 cm accuracy standards requirement.

An orthometric level connection is preferred over ellipsoidal GPS tie, where applicable, for deriving NAVD 88 heights. An orthometric level connection is required if any geodetic marks (up to five marks) are located within a radius of 0.8 km (0.5 miles) from the subordinate tide station location. If suitable marks are found in the NGS database, and are farther than 0.8 km (0.5 miles) but less than 10 km (6.25 miles) from a subordinate tide station, then a GPS tie is required to derive the ellipsoid heights. If a minimum of five existing tidal bench marks within 1 km of a subordinate tide station location are not found, or suitable geodetic marks are not found in the NGS database within 10 km (6.25 miles) of a subordinate tide station, then five new bench marks shall be installed, described, and connected by levels. (Refer to *User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2002.*)

At least two geodetic bench marks should be used to validate the leveling or GPS ellipsoid height connection for quality control purposes. In addition, at stations with no geodetic bench marks located nearby, GPS ellipsoidal heights shall be established for at least three of the bench marks in the local tide station network. (One base station and two subordinate marks.)

3.7. Tide Staffs and observations

Staff

The contractor shall install a tide staff at a station if the zero of a gauge cannot be directly leveled to local bench marks such as a pressure based bubbler gauges. Even if a pressure gauge can be leveled directly, staff readings are still required for assessment of variations in gauge performance due to density variations in the water column over time. When the station is on a pier or wharf, the staff shall not be mounted to the same pile on which the water level sensor is located. The staff shall be plumb. When two or more staff scales are joined to form a long staff, the contractor shall take extra care to ensure the accuracy of the staff throughout its length. The distance between staff zero and the rod stop shall be measured before the staff is installed and after it is removed.

In areas of large tidal range and long sloping beaches (i.e. Cook Inlet and the Gulf of Maine), the installation and maintenance of tide staffs can be extremely difficult and costly. In these cases, the physical installation of a tide staff(s) my be substituted by systematic leveling to the water's edge from the closest bench mark. The bench mark becomes the "staff stop" and the elevation difference to the water's edge becomes the "staff reading".

Staff Observations

If a gauge requiring independent staff readings is installed, the installation report must be accompanied by a 3-hour set of staff-to-gauge observations documenting the proper operation of the gauge. During the first or second day of gauge operations, the gauge and staff must be read simultaneously and recorded every 6 minutes for a 3-hour period. The staff-to-gauge differences should remain constant throughout the set of observations and show no increasing or decreasing trends. Gauge time should be set to Coordinated Universal Time (UTC). The gauge and staff shall be read simultaneously and recorded once a day (minimum of three days in each seven day period) for the duration of the water level measurements. The average staff-to-gauge difference shall be applied to water level measurements to relate the data to staff zero. A higher number of independent staff readings decreases the uncertainty in transferring the measurements to station datum and the bench marks. See Figure 2 for an example pressure tide gauge record.

Figure 2 Example - Pressure Tide Gauge Record

PRESSURE TIDE GAUGE RECORD

Station Name: ______________________________ **Station No. (7 digit #)** ______________________

Date	Time		Staff Reading		Gage/Staff	Gas Pressure		Wind	Air	
(M,D,Y)	Gage	Correct	High	Low	Diference	Cyln	Feed	(Dir/Spd)	Temp.	Remarks

3.8 GPS Observations

GPS observations are required to obtain elevation ties between the tidal datums and GPS derived datums.

(A) High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites.

A choke ring antenna is preferred, however, any geodetic quality ground plane antenna may be used. More important than antenna type, i.e. choke ring or ground plane, is that the same antennas or identical antennas should be used during the entire observing sessions. If not, a correction for the difference in antenna phase patterns (modeled phase patterns) must be applied. This is extremely critical for obtaining precise vertical results. The antenna cable length between the antenna and receiver should be kept to a minimum when possible; 10 meters is the typical antenna cable length. If a longer antenna cable is required, the cable must be fabricated from low loss coaxial cable (RG233 for up to 30 meters and RG214 over 30 meters).

(B) A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, 2 meter pole with three adjustable legs, a bulls eye bubble to plumb the antenna, and a magnetic compass to align the antenna to North. These fixed height tripods reduce the chance of introducing an Height of Instrument (HI) “blunder” during the post-processing of the data.

(C) The manufacturer, model, and complete serial numbers of all receivers and antennas must be included for each occupation on each station/bench mark observation log sheet as shown in Figure 4.18

(D) The station bench mark selected for GPS observations shall have stability code either an A or B. GPS observations on the PBM are preferred if the PBM has the stability code of A or B and also if it is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. It may be necessary to select new GPS marks, or set new marks, at some stations to ensure stability over time as the case may be.

(E) Additional GPS suitable marks shall also be connected during the static survey using rapid static GPS procedures to verify bench mark stability, if time and personnel resources are available. Priority shall be given to connecting to the NSRS, particularly to the North American Vertical Datum of 1988 (NAVD 88) bench marks.

(F) All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. A note shall be made, either in the APP field of the electronic leveling HA file, if electronic levels are used, or on the bench mark descriptions sheet, stating the suitability of GPS observations for each mark. GPS visibility obstruction diagram shall also be completed for each mark observed as shown in Figure 4.20.

(G) The most desirable bench mark for GPS observations will have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have the required clearances, if at all possible. Public property is usually a good location choice. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new 3-D rod mark or a mark installed in rock outcrop with stability A shall be established according to NOS standard procedure. This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

(H) Static GPS surveys shall be conducted on a minimum of one bench mark, preferably two marks if time and resources permit, at each subordinate water level station installed/occupied for hydrography.

(I) Static GPS surveys shall be conducted at water level stations concurrently with the occupation of NAVD 88 marks, if possible, to accomplish water level datum transfers using GPS-derived orthometric heights.

(J) A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 4.22. If digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 4.21. A digital photo of the stamping is preferred over rubbing of the mark.

(K) Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites

(L) The length of GPS observation sessions depends upon the length of the time field crew has available for GPS observations, number of satellites available at a site, number of bench marks available for GPS observations, etc. <u>The basic requirement for GPS observations on a bench mark is minimum two sessions of 6 hours each and both sessions should begin with proper antenna setup.</u> The two GPS observation sessions on the same bench mark shall be done on the same day or on two different days. When two sessions are done (whether on the same day or on two different days), then close down the antenna at the end of the first session and re-setup the antenna at the beginning of the second session. If two sessions are done on the same day, then start the second session at least after ½ hour after the completion of the first session. If two GPS observation sessions are selected on two different days, then ideally the second session should start 28 hours after the beginning of the first session so that a different set of GPS satellites are available for the second session. When two sessions are done on the same day, the gap between the end of the first session and the beginning of the second session can be, or need to be increased if PDOP is not suitable for observations, this is applicable only if PDOP information is available to the field crew.

For contract and NOAA hydrographic surveys and special projects three GPS observation sessions of 6 hours each on two or three different days are recommended, if time and resources permit. If three GPS sessions are done then they should be spread over minimum two different days. Two GPS sessions can be done the same day, or on two different days.

If only one GPS observation session is possible for the available time, then record minimum of 24 hours of GPS observations on a bench mark. Minimum two GPS observation sessions of 6 hours each are preferred over one long 24 hour GPS session.

Always collect a little bit of extra data if time and schedule permit, so that blunders or invalid data, if any, can be removed during processing still leaving minimum of 24 hours of valid data for one GPS session, or 6 hours of valid data for each session for two (or three as the case may be) GPS sessions.

(M) It is recommended that after the session is complete, two independent downloads be done from the GPS receiver to the laptop computer, so that if one downloaded file gets corrupted, the other file may have good data. Since two downloads of the GPS observation file is a requirement, do not make copy of the downloaded file twice to the laptop instead, as both the files will have the same problem, if there exists a problem. Send both copies of digital GPS data so that one copy of the data can be forwarded to NGS and other copy will be kept for record in CO-OPS.

(N) Meteorological data (air temperature, barometric pressure, and relative humidity) need to be collected, if available, during the GPS observations. Collect appropriate meteorological data at the beginning, middle, and at the end of each GPS session, if a sensor is available and GPS session length is greater than 2 hours. If a sensor is available, then air temperature must be observed and recorded to the nearest 1° Celsius, and barometer must be observed and recorded to at least nearest 1 millibar. Meteorological data should be collected at or near the antenna phase center. All equipment should be checked for proper calibration periodically.

If none of the meteorological sensors (air temperature, barometric pressure, and relative humidity) are available for recording observations, then note any change in the atmospheric conditions on the GPS station/bench mark observation log form under Remarks section.

(O) GPS (horizontal) positions (latitude and longitude) of each bench mark installed or recovered shall be listed on the HA files for laser levels, if used, or on the bench mark descriptions sheet for optical leveling, as applicable, at each subordinate water level station occupied for hydrography.

(P) Refer to Section 4. for GPS Project Documentation requirements later in this document.

4. Station and Data Submission Documentation

The field team shall maintain a documentation package for each water level measurement station installed. The documentation package shall be forwarded to CO-OPS within 15 business days of a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, or d) removal of the station.

Generally, all documentation submitted (refer to Section 4.1 for Station Documentation) shall be forwarded to CO-OPS when a station is installed. For other situations, only information that has changed shall be submitted (e.g., levels and abstract for bracketing or removal levels, NGWLMS Site Report for maintenance and repair or station removal, etc.).

Data submission requirements for water level measurement stations are comprised of both supporting documents for the installation, maintenance, and removal of stations, and the formatted digital water level data collected by the water level measurement system required for NOS quality control and ingestion into the NOS data base management system.

Data submission requirements for GPS projects consists of project reports, station (bench mark) description or recovery notes, observation log sheets, station visibility diagrams, photographs or rubbings of station marks, raw GPS data, Rinex GPS data, and other info as pertinent (refer to Section 4.2 for GPS Project Documentation).

4.1. Station Documentation

Refer to Figure 3 Water Level Station Documentation Checkoff List during submission of station documents. The station documentation generally includes, but is not limited to the following:

(a) Field Tide Note

(b) Calibration test documentation from an independent source other than the manufacturer for each sensor used to collect water level or ancillary data.

(c) NGWLMS Site Report (see *Next Generation Water level Measurement System Site Design, Preparation, and Installation Manual*) , and/or Tide Station Report (NOAA Form 77-12), or Great Lakes Water Level Station Report (NOAA Form 77-75).

(d) New or updated Nautical chart section or U.S. Geological Survey quadrangle map indicating the exact location of the station, with chart number or map name and scale shown.

(e) Large-scale sketch of the station site and digital GIS compatible file provided on diskette showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (derived from handheld GPS) of the gauge and all bench marks.

(f) New or updated description of how to reach the station from a major geographical landmark.

(g) Photographs of station components and bench marks. Digital photographs are preferred. As a minimum, photographs shall show a view of the water level measurement system as installed, including sensors and DCP; a front view of the staff (if any); multiple views of the surroundings and other views necessary to document the location; and photographs of each bench mark, including a location view and a close-up showing the bench mark stamping. All photographs shall be annotated and referenced with the station name, number, location, and date of the photograph.

(h) Description/Recovery Notes of Bench Marks (refer to *User's Guide for Writing Bench Mark Descriptions*, NOAA/NOS, Updated January 2002).

(i) Level records and level abstract, including level equipment information.

(j) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor "zero" is referenced to the bench marks.

4.2. GPS Project Documentation

The following information shall be submitted to CO-OPS at the end of the project so that proper information can be forwarded to NGS.

This documentation is important because most of the information is used to submit the GPS data to NGS. In addition to the log, data must comply with the "Data Submission to NGS Section" of NGS-58 and the "Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base" to become part of the NSRS.

GPS data collected by contractors or NOAA Ships for hydrographic survey support, or special projects shall be processed by the parties, and final data product - Receiver Independent Exchange Format (RINEX) data and appropriate forms - shall be submitted to CO-OPS which will be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

GPS forms in PDF format can be found at the following NGS Federal Base Network web site:

http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm

Refer to Figures 4 through 9 for GPS projects submission checklist and sample package contents.

(a) Project report (Refer to Figure 4):
One project report per GPS project is required.

(b) Station (bench mark) description or recovery notes (Refer to Figure 5)
One per bench mark, for which GPS observations are submitted, is required.

(c) Observation log sheets (Refer to Figure 6 and 7)
One per each GPS observation session is required.

(d) Station/bench mark visibility diagrams (Refer to Figure 8)
One per each bench mark, for which GPS observations are submitted, is required.

(e) Photographs or rubbings of station (bench) marks (Refer to Figures 9 and 10)
One per each bench mark, for which GPS observations are submitted, is required.

(f) Raw GPS data

(g) Rinex GPS data

Figure 3

I. **For Each Water Level Station:**

PROJECT DOCUMENTATION AND DATA CHECKOFF LIST

Project Number: ____________ Locality: ____________________

Station Number: _____________ Station Name: _______________

A. **Field Tide Note**

____ 1. Verify latitude and longitude with handheld GPS.
____ 2. Verify dates.

B. **Site Report (required for both installation and removal)**

____ 1. All applicable information complete, especially serial numbers of DCP/sensors and dates of installation/removal of DCP/sensors and levels.
____ 2. Verify latitude and longitude (ensure that this is the same as on the field tide note).
____ 3. Denote latitude and longitude as NAD 83. Also note if position was derived from handheld GPS.

C. **Chart Section**

____ 1. Ensure that station location is clearly depicted with circle and station number.
____ 2. Note chart number, edition, date and scale.

D. **Bench Mark/Station Location Sketch**

____ 1. Gage/staff and bench marks shown.
____ 2. Title block provided (NOAA Form 76-199).
____ 3. North arrow depicted.
____ 4. Include hard copy sketch and GIS digital format on diskette.

E. **Photographs**

____ 1. Digital photographs of gage, staff and surrounding area.

F. **Bench Mark Descriptions/Recovery Notes**

____ 1. Stampings for new and recovered marks verified.
____ 2. Descriptions for new marks provided in NOS format (WP 6.0).

Figure 3 (continued)

____ 3. Recovery notes provided for all historical marks.

G. Levels (NOAA Form 76-77 or Form 75-29)

____ 1. Ensure all information written in ink.
____ 2. Cover information complete; station name, number, instrument and rod type, serial numbers, date, personnel.
____ 3. Note types of levels; installation, bracketing and closing.
____ 4. Staff information complete (if applicable).
____ 5. Collimation check shown.
____ 6. Note that bench mark descriptions are submitted on separate sheets.
____ 7. Headers on all applicable pages complete.

H. Datum Offset Computation Worksheet

_____ 1. Submit for stations using Vitel or Sutron DCP with Aquatrak water level sensor.

I. Data Submitted on Diskettes

____ 1. Label diskettes with contractor name and list of files on each diskettes.
____ 2. Data files should be named in the following format: xxxxxxx1.dat, where x= station number and 1 is the DCP designation. For multiple files from the same station, change the extension, i.e., xxxxxxx1.da1, da2, etc.
____ 3. Check the begin and end dates of data submitted with dates of hydrographic operations.
____ 4. Check data continuity.

Figure 4 **PROJECT SUBMISSION CHECKLIST**
GPS PROJECTS

Project Title : ____

Submitting Agency: ____

Observing Agency: ____

Receiver Type: ____

Antenna Type: ____

PACKAGE CONTENTS

( ) Project Report

( ) Station Description or Recovery notes

( ) Observations Logs Sheets
Data which must be filled out: Station Designation, Date (UTC), General Location, Day of Year, Project Name, Session ID, Observation Session Times, Agency Full Name, Operator Full Name, Phone Number, GPS Receiver, GPS Antenna, Antenna Height, Data File Name

( ) Station Visibility Diagrams

( ) Photographs or Rubbings of Station Marks

( ) Raw GPS data

( ) Rinex GPS Data - See below

( ) Other

DATA REFORMATTING

Convert the raw GPS data to RINEX2 format with your manufacturer's software. The software should require you to enter the raw data filename, the output filenames, your name, the observer's name and agency, and the antenna type used.

The NGS-standard data filenames are as follows:

Raw GPS input files: aaaaddds.xxx
Where: aaaa = alphanumeric 4-character station identifier, ddd = day of year, s = session, yy = year of observations, and xxx is the receiver-dependent file extension
(e.g., .DAT, .EPH, .ION, .MES, etc.)

RINEX2 Navigation File: aaaaddds.yyn
RINEX2 Observation File: aaaaddds.yyo

For example, RINEX2 filenames from station BALD 2 on session A of 12/31/98 are BALD365A.98o and BALD365A.98n

Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch diskettes or CD ROM.

Figure 5: Station (Bench mark) Description/ Recovery Form

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY
STATION DESCRIPTION / RECOVERY FORM

PID: QE2736 Designation & Alias: BALD 2 RESET

Country: (USA / USA) State: OR County: LINCOLN

Latitude: N 44 49 49.17802 " Longitude: W 124 03 56.23447 " Elevation: 17.0 (meter / ft)

Original Description (check one):	
☐ P	Preliminary (mark has not been set yet)
☐ D	A newly set mark
☑ R	A recovered mark
Established by: (NGS / CGS / Other:) Oregon DOT	
Date:	Chief of Party (initials): ???

Recovery Description (check one):	
☐ F	Full description of a station *not* in the database
☑ T	Full description of a station *in* the database
☐ M	*Partial* description of a station in the database
Recovered by: (NGS / Other:) Oregon DOT	
Date:	Chief of Party (initials): CFS

Monument Stability (check one):	
☑ A	Of the most reliable nature; expected to hold well
☐ B	Will probably hold position and elevation well
☐ C	May hold well, but subject to ground movement
☐ D	Of questionable or unknown reliability

Recovery Condition (check one):	
☑ G	Recovered in good condition
☐ N	Not recovered or not found
☐ P	Poor, disturbed, or mutilated
☐ X	Surface mark known destroyed

Setting Information:	
Marker Type: (Rod / Disk / Other)	
Setting Type: (Bedrock / Concrete / Other:)	
✔ / N / ?	Monument contains magnetic material?

Stamping:	BALD 2 1991
Agency Inscription: (NGS / CGS / Other:)	Oregon DOT
Rod Depth: (meter/ft), Sleeve Depth: (meter/ft)	
Monument is: (flush / projecting / recessed)	(cm/inch)

Special Type (check all applicable):	
☐ F	Fault monitoring site
☐ T	Tidal Station
☑ --	Control Station: (FBN / CBN / Bench mark)
☐ --	Airport Control Station: (PACS / SACS)
✔ /N	Mark is suitable for GPS use?

Transportation (check one):	
☑ C	Car
☐ P	Light truck (pickup, carry-all, etc.)
☐ X	Four-Wheel Drive Vehicle
☐ __	Other (SnowCat, Plane, Boat; describe)
✔ /N	Pack Time (hike) to mark? (hh:mm): 00:03

See Back of Form to add Text Description

General Station Location: The station is located in about 10 km south from Lincoln Bay, 13 km north from Depoe Bay, and at the US101 Boiler Bay wayside rest area.

(Describe general location; include airline distances to three towns or mapped features.)

Ownership: The station is on the property of Oregon State Department of Parks and Recreation.

(name, address, phone of landowner)

To Reach Narrative: To reach the station from the intersection of US routes 5 and 101 in Depoe Bay, go north on US 101 for 1 km to the south entrance of the Boiler Bay wayside. Bear left on entrance road for 0.4 km to the parking area on the left. Pack northwest inside fence for about 90 meters to end of fence and the station on the right.

(Leg-by-leg distances and directions from major road intersection to mark)

Monument Description and Measurements: The station is set into drill hole in bedrock, 7.6 m south from the north fence corner, 8.8 m east from the west fence corner, and 3.6 m southeast from the northwest end of the outcrop.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

NOTE: - Include a pencil rubbing, sketch, or photographs of mark.

Described by: John Q. Surveyor Phone: (301) 713-3194 e-mail: jqs@ordot.gov

Figure 6: GPS Station Observation Log

--> Click here to clear the sample data <--

GPS STATION OBSERVATION LOG (01-Nov-2000)	Station Designation: (check applicable: FBN / CBN / PAC / SAC / BM) BALD 2 RESET	Station PID, if any: QE2736	Date (UTC): 31-Dec-98
	General Location: Boiler Bay Wayside; Airport ID, if any: ---	Station 4-Character ID: BALD	Day of Year: 365
Project Name: Sample GPS, 1998	Project Number: GPS- 1234	Station Serial # (SSN):	Session ID:(A,B,C etc) A

NAD83 Latitude: 44 ° 49 ' 49.17802 "	NAD83 Longitude: 124 ° 03 ' 56.23447 "	NAD83 Ellipsoidal Height: -6.44 meters	Agency Full Name: Oregon DOT
Observation Session Times (UTC): Sched. Start 12:00 Stop 17:30; Actual Start 11:55 Stop 17:32	Epoch Interval= 15 Seconds; Elevation Mask = 10 Degrees	NAVD88 Orthometric Ht. 17.0 meters; GEOID99 Geoid Height -23.52 meters	Operator Full Name: John Q. Surveyor; Phone #: (301) 713-3194; e-mail address: jqs@ordot.gov

GPS Receiver:
Manufacturer & Model: Leica SR530
P/N: p/n 667122
S/N: s/n 0030354
Firmware Version: Version 3.0
☑ CamCorder Battery, ☐ 12V DC, ☐ 110V AC, ☐ Other

GPS Antenna:
Manufacturer & Model: Trimble Choke Ring
P/N: p/n 29659-00
S/N: s/n 02200-63591
Cable Length, meters: 30 meters
Vehicle is Parked 25 meters N (direction) from antenna.

Antenna plumb before session? ✔Y / N
Antenna plumb after session? ✔Y / N
Antenna oriented to true North? ✔Y / N
Weather observed at antenna ht ✔Y / N
Antenna ground plane used? ✔Y / N
Circle Yes or No -If no, explain "

Antenna radome used? (Y / N)✔
Eccentric occupation (>0.5 mm)? (Y / N)✔
Any obstructions above 10º? (Y / N)✔
Radio interference source nearby (Y / N)✔
If yes, describe. Use Vis. form

Tripod or Ant. Mount: Check one:
☑ Fixed-Height Tripod, ☐ Slip-Leg Tripod, ☐ Fixed Mount
Manufacturer & Model: SECO
P/N: none.
S/N: 97-G
Last Calibration date: 1998-11-01

Tribrach: Check one:
☑ None, ☐ Wild GDF 22, ☐ Topcon, ☐ Other (describe)
Last Calibration date:

** ANTENNA HEIGHT ** (see back of form for measurement illustration)	Before Session Begins: measure and record both Meters	Feet	After Session Ends: measure and record both Meters	Feet
A= Datum point to Top of Tripod (Tripod Height)	2.000		2.000	
B=Additional offset to ARP if any (Tribrach/Spacer)	-0.003		-0.003	
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)				

Note: Meters = Feet X (0.3048)
Height Entered Into Receiver = 2.000 meters.

Please note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer:
Manufacturer & Model: pretel altiplus A2
P/N: none.
S/N: J.Q.S.
Last Calibration or check Date: 11-Sep-01

Psychrometer:
Manufacturer & Model: Psychrodyne
S/N: J.Q.S.

Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit	Celsius	WetBulb Temp Fahrenheit	Celsius	Rel. % Humidity	Atm. Pressure inches Hg	millibar	Weather Codes *
Before	12:00	74.0		68.0		74	29.4		00000
Middle	14:45	77.0		72.5		81	29.6		00001
After	17:30	82.5		78.0		82	29.7		00102
Average of Readings				Calculate					* See back of form for codes

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

1. Winds, calm at start, gradually increased to 20 knots by end of session.

2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment.

3. Center pole of tripod projected 3 mm into dimple of disk.
Antenna height was therefore 2 m - 3 mm = 1.997 m

Note: Entries are Required in all Unshaded areas.

Data File Name(s): BALD365A.dat
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ☑ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☑ Attached ☐ Submitted earlier
Photographs of Station: ☑ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☑ Attached

LOG CHECKED BY: JGE

Figure 7: GPS Antenna Height Measurements

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length **(A)** and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) **(B)**

$$Antenna.Height = H = A + B$$

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm	223.40	223.30	223.30	
Before, inch	87.95	87.94	87.93	
After, cm	223.40	223.40	223.30	
After, inch	87.97	87.96	87.95	
Note: cm= inch x (2.54)	Overall average, cm			

S = ________________ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

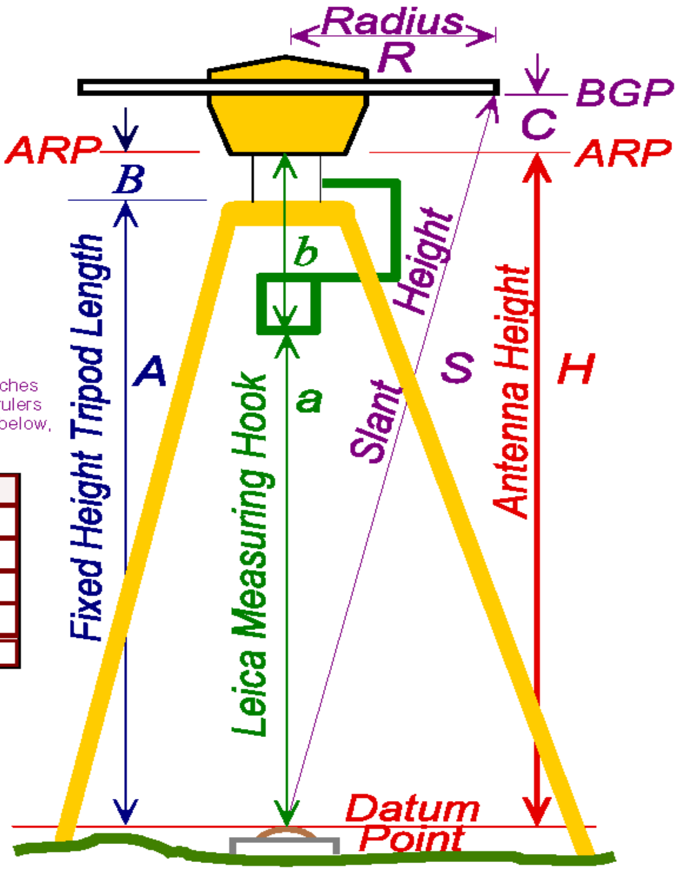
R = ____19.05____ cm

C = ____3.50____ cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$Antenna.Height = H = ((\sqrt{S^2 - R^2}) - C)$$



III. Instructions for using the Leica Brand Measuring Hook:

Follow the Leica operating instructions, being sure to reduce the height to the Antenna Reference Point (ARP), NOT the L1 Phase Center.

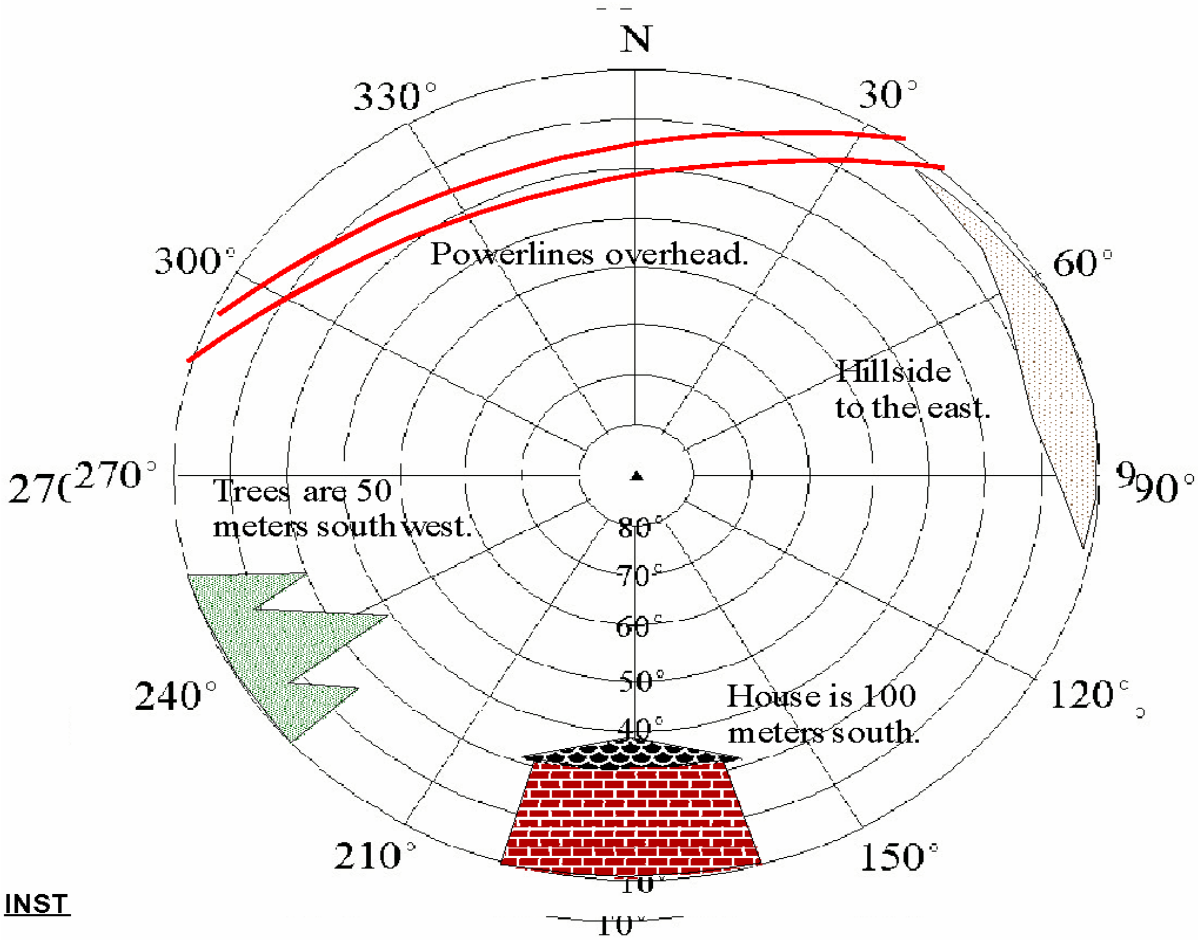
$$Antenna.Height = H = a + b$$

Table of Weather Codes -- for entry into Weather Data Table on front of form:					
CODE	**PROBLEM**	**VISIBILITY**	**TEMPERATURE**	**CLOUD COVER**	**WIND**
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80°F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80°F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over15mph (24km/h)
Examples: Code 00000 = Code 12121 =	0 - No problems, 1 - Problems,	0 - good visibility, 2 - poor visibility,	0 - normal temperature, 1 - hot temperature,	0 - clear sky, 2 - overcast,	0 - calm wind 1 - moderate wind

Figure 8: Visibility Obstruction Diagram

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY
VISIBILITY OBSTRUCTION DIAGRAM



INST

Identify obstructions by azimuth (magnetic) and elevation angle (above horizon) as seen from station mark.
Indicate distance and direction to nearby structures and reflective surfaces (potential multipath sources).

Designation: BALD 2 RESET PID: QE2736

Location: Boiler Bay Wayside County: LINCOLN

Reconnaissance By: John Q. Surveyor Height above mark: 2 Meters

Agency/Company: Oregon DOT Phone: (301) 713-3194 Date: 1998-12-31

Figure 9: Station Pencil Rubbing Form

Station Pencil Rubbing Form

--> Click here to clear the sample data <--

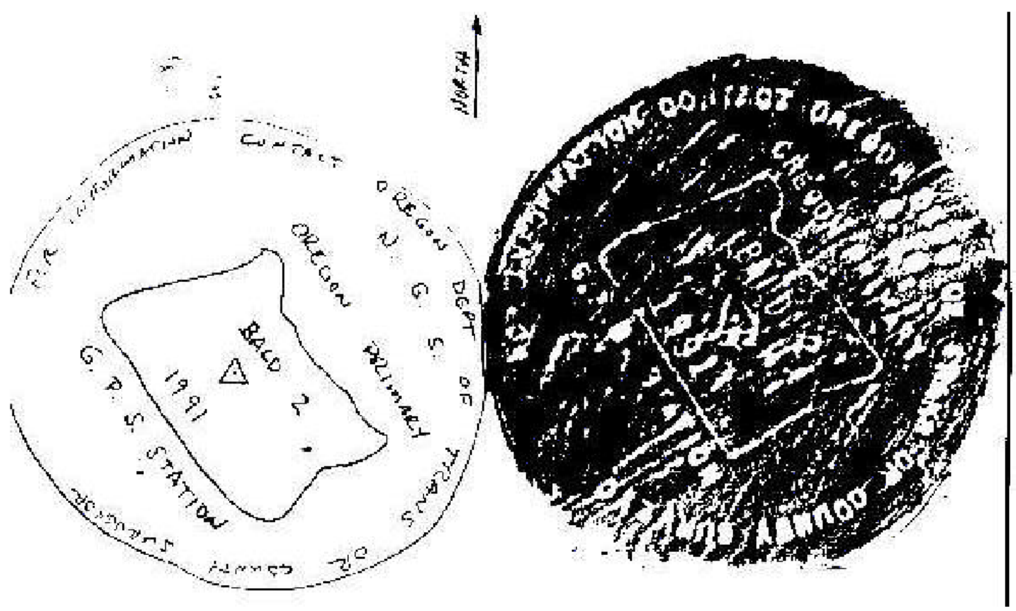
Location / Airport Name and ID: Boiler Bay Wayside   Project: Sample GPS, 1998

Station Designation: BALD 2 RESET   PID: QE2736   Date: 1998-12-31

Circle all applicable: PACS SACS ✓BM FBN ✓CBN OTHER________   Observer & Organization: John Q. Surveyor, ORDOT

Station Pencil Rubbing

Instructions: Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.



Remarks:
This disk is reset into the same drill hole as the original station BALD 1962.

Monument Type: Brass Disk

Inscribed Agency: Oregon DOT

Stamping: BALD 2 1991

Figure 10:: Digital Photograph of a Stamping of a Bench Mark

4.3. Water Level Data

The final observed water level measurements shall be reported as heights in meters to three decimal places (i.e. 0.001 m). All heights shall be referenced to station datum and shall be referenced to UTC. The final tide reducer time series data shall be referenced to MLLW and shall be referenced to UTC. The contractor must provide CO-OPS with the water level data from all tide gauges installed with in 90 days of removal of stations/gauges.

The original raw water level data shall be retained until notified in writing or at least two years after the project is completed. All algorithms and conversions used to provide data shall be fully supported by the calibrations, maintenance documentation, leveling records, and sound engineering/oceanographic practices. Sensors for measurements used to convert data (e.g. pressure to heights) shall be calibrated and maintained for the entire water level collection period.

All digital water level and ancillary data shall be transmitted to CO-OPS in a format dependent on the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo binary format (see NGWLMS GOES Message Formatting, Libraro, 1998). These satellite messages are then decoded by NOS DMS upon receipt from NESDIS before further processing and review by CORMS can be completed. If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to NOS at least monthly, by the 15th of the month, in the format below on 3.5 inch floppy disk, CD-ROM, registered mail, FEDEX, or by email as an ASCII data attachment. It may be prudent to submit data at more frequent intervals under specific circumstances. Data download files shall be named in the following format: xxxxxxxy.DAZ, where x is the seven digit station number, y is the DCP number (usually 1), and DAZ is the extension (where Z = 1,2,3...if more than one file is from the same station and DCP). This is the format needed when the data is loaded into DMS.

The 6-minute interval data (acoustic sensor and pressure sensor examples follow) shall have the following format once decoded:

Acoustic Sensor Data (XXX.ACO format)

Column 1-7	Station ID (assigned in the project instructions)
Column 8	1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19	Date (MMM DD YYYY format, e.g. JAN 01 1998)
Column 20	Blank
Column 21-22	Hours in 24 hour format (i.e. 01, 01, ..., 23)
Column 23	: (place a colon)
Column 24-25	Minutes (00,06,12,etc..)
Column 26-32	Data value in millimeters, right justified, (e.g. 1138)
Column 33-38	Sigma (standard deviation in millimeters in integer format)
Column 39-44	Outlier (integer format)
Column 45-50	Temperature 1 (tenth of degrees C in integer format)
Column 51-56	Temperature 2 (tenth of degrees C in integer format)
Column 57-58	Sensor type (A1 for acoustic type)

Column 59-60	blank
Column 61-61	Data Source (S for Satellite, D for Diskette)

Sample data:

```
85169901AUG 17 1993 05:00   1138   23   0  308  297A1 S
85169901AUG 17 1993 05:06   1126   26   0  308  298A1 S
85169901AUG 17 1993 05:12   1107   26   1  309  298A1 S
```

Pressure Sensor Data (XXX.BWL format)

Column 1-7	Station ID (assigned in the project instructions)
Column 8	1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19	Date (MMM DD YYYY format, e.g. JAN 01 1998)
Column 20	Blank
Column 21-22	Hours in 24 hour format (i.e. 01, 01, ..., 23)
Column 23	: (place a colon)
Column 24-25	Minutes (00-59)
Column 26-32	Data value in millimeters, right justified, (e.g. 1138)
Column 33-38	Sigma (standard deviation in millimeters in integer format)
Column 39-44	Outlier (integer format)
Column 45-50	DCP temperature (tenth of degrees C in integer format)
Column 51-52	Sensor type (B1 for pressure type)
Column 53-53	blank
Column 54-54	Data Source (S for Satellite, D for Diskette)

```
85169901AUG 17 1993 05:00   1138   23   0  308B1 S
85169901AUG 17 1993 05:06   1126   26   0  308B1 S
85169901AUG 17 1993 05:12   1107   26   1  309B1 S
```

Note: pressure data must be accompanied by documented daily staff readings.

4.4. Submission

The check list in Figure 3 shall be used to check and verify the documentation that is required for submission. All documentation, water level data, GPS info and data, and other reports as required shall be forwarded to the following address:

NOAA, National Ocean Service
Thomas Mero
Chief, Requirements and Development Division
SSMC4 - Station 6531, N/OPS1
1305 East-West Highway
Silver Spring, MD 20910
Phone: 301-713-2897 ext. 145
Fax: 301 - 713-4436

5. References

References for the water level measurement and leveling requirements issued by the NOS Center for Operational Oceanographic Products and Services (CO-OPS) and the National Geodetic Survey (NGS) are listed below.

1 Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991.

2. User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, NOAA/NOS, dated October 1987.

3. User's Guide for Writing Bench Marks Descriptions, NOAA/NOS, Updated January 2003.

4. User's Guide for Electronics Levels, NOAA/NOS, Updated January 2003.

5. User's Guide for 8200 Bubbler Gauges, NOAA/NOS, updated February 1998.

6. User's Guide for 8200 Acoustic Gauges, NOAA/NOS, updated August 1998.

7. User's Guide for GPS Observations, NOAA/NOS, updated January 2003.

8. NGWLMS GOES MESSAGE FORMATTING, Phil Libraro, 6/98.

9. Standards and Specifications for Geodetic Control Networks, Federal Geodetic Control Committee, September 1984.

10. Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2CM and 5CM) Version 4.3, NOAA Technical Memorandum NOS NGS-58, November 1997.

11. Geodetic Leveling, NOAA Manual NOS NGS 3, U.S. Department of Commerce, NOAA, National Ocean Survey, August, 1981.

12. Manual of Tide Observations, U.S. Department of Commerce, Publication 30-1, Reprinted 1965.

13. Tide and Current Glossary, U.S. Department of Commerce, NOAA, NOS, October 1989.

14. Standing Project Instructions: Great Lakes Water Levels, June 1978.

15. System Development Plan, CORMS: Continuous Operational Real-Time Monitoring System, NOAA Technical Report NOS OES 014, U.S. Department of Commerce, NOAA, NOS February, 1997.